Palynology of Iron Age and Gallo-Roman Sediments from Beaurieux Les Grèves, Aisne, France.

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Abstract

Pollen and non-pollen palynomorph analyses conducted on archaeological sediments from ditches and pits are used to investigate land use and vegetation history around the long-lived rural settlement of Beaurieux Les Grèves in the Aisne valley, Picardy, northern France. Samples were examined from successive phases spanning the 8th century BC to the 3rd century AD. Each phase showed evidence of agriculture and human impact on the environment. The earliest occupation was early Iron Age and the area around the site was shown to have been almost completely deforested and dominated by open ground and pasture. The later Iron Age supported mixed agriculture, probably with pasture around the site and cereal fields further away. In Gallo-Roman times there was mixed farming with considerable cereal cultivation, although the area around the site was mainly pasture or waste land. Late Gallo-Roman times saw a reduction in the scale of agricultural activity and some regeneration of natural heath and scrub vegetation. Coprophilous fungal spores are conspicuous and indicate the importance of animal husbandry on and around the site. The data from Beaurieux Les Grèves augment earlier analyses from settlements and natural deposits in the Aisne valley in suggesting almost complete deforestation for agricultural land use within the valley bottom, although some woodland undoubtedly survived on the steeper valley sides and nearby plateaux. It agrees with the pollen evidence from the wider region of north-eastern France that clearance of *Fagus*-dominated woodland for mixed agriculture in late Iron Age and Gallo-Roman times, and increasingly for arable cultivation, transformed the regional vegetation to one of partly wooded but mainly open character.

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Introduction

The valley of the river Aisne, in southern Picardy, is rich in important archaeological sites of different periods, and its gravel terraces and floodplain are today one of the most intensively studied archaeological landscapes in Europe (e.g. Auxiette and Malrain 2005; Bostyn and Hachem 2015). Considerable attention has been paid to the Iron Age (e.g. Pion 1990; Gransar et al. 1999; Haselgrove 2007a; Paris 2016), and notable amongst the late Iron Age sites of northern France are the large fortified '*oppida*' on the alluvial terraces of the Aisne, such as Villeneuve-Saint-Germain (Ruby and Auxiette 2010; Auxiette and Paris 2017). There was also extensive Iron Age and Gallo-Roman rural settlement in the valley, as well as on the adjacent slopes and plateaux (Pion et al. 1996; Duvett 2017). In the initial phase of archaeological intervention driven by gravel extraction, these latter zones received little attention, but this has been redressed by a combination of aerial survey (Boureux 1982), fieldwalking (e.g. Haselgrove 1996) and the extension of development-led excavations to the plateaux (e.g. Gransar 2005). This work has greatly enhanced our knowledge of the number, distribution and character of rural sites in the different zones, and established their importance for understanding social, economic and cultural history in the periods leading up to, and following, the imposition of Roman rule (e.g. Bayard 1996; Ben Redjeb et al. 2005; Malrain et al. 2005; Bayard et al. 2011; 2014).

This paper presents the results of pollen and non-pollen palynomorph analyses conducted on archaeological samples taken from ditches and pits during excavations at Beaurieux Les Grèves, one of a number of sites investigated in the Aisne department as part of a long-term project by Durham University during the 1980s and 90s exploring Iron Age and Gallo-Roman settlement patterns. The data are used to explore changing land use and vegetation history around the site over a thousand years from the earlier 1st millennium BC to the mid-1st millennium AD.

The Study Site

The long-lived farmstead of Beaurieux Les Grèves, lies in the middle Aisne valley, about 25 km east of Soissons (Fig. 1). It is located on the lower gravel terrace, which was covered by loess in prehistoric times, close to the river and just above the current floodplain. One of the first multi-period rural settlements in the region to be extensively excavated, the site remains one of very few in the valley bottom with a sequence spanning much of the Iron Age and Gallo-Roman periods (Haselgrove 1996; Haselgrove and Lowther forthcoming). The 1980s excavations revealed six main structural phases (Fig. 2): an early Iron Age palisaded enclosure, which was subsequently enlarged (Phase 1) a late Iron Age open settlement (Phase 2), successive early Roman rectangular enclosures (Phases 3-4), and a Gallo-Roman villa (Phases 5-6). Several centuries separated the palisaded settlement, dating between

the 8th and 6th centuries BC (Hallstatt C-D) from the later 2nd and early 1st century BC open settlement (La Tène D1) with its timber buildings, wells and pits. After a short break, a large rectilinear ditched enclosure that included several buildings was established in the late 1st century BC, around the start of the Augustan period. Archaeobotanical data indicate that these structures included both domestic and agricultural buildings, probably barns (Bakels 1999). This farmstead was in turn replaced in the 1st century AD by a smaller enclosure and new buildings, later followed by a Gallo-Roman villa. This was reorganized at the end of the 3rd century AD after a period of decline, but occupation continued on a reduced scale until the mid-4th century AD, when the site was finally abandoned. Renewed excavations in 2011–12 prior to possible gravel extraction have added to our knowledge of the site layout (Hénon et al. 2015) Trenching revealed two more early Iron Age palisaded enclosures to the south of the complex excavated in the 1980s and confirmed the existence of another Gallo-Roman site focus, already suspected from fieldwalking, 200 m to the north-west. This was occupied from the later 1st century AD and may be a farmyard area for the stone villa (ibid: 276; V. Le Quellec pers. comm.).

Beaurieux thus presents one of the longest and most complex rural settlement sequences in the Aisne valley region, representing around 800 years of occupation with only one major interruption, in the middle Iron Age. Its many excavated gully, pit and ditch fills provide an excellent opportunity for the archaeobotanical, including palynological, investigation of long-term changes in agriculture and land use. Analysis of the seeds and other plant macrofossil remains from these contexts indicates that all could have originated from the immediate environs of the settlement and that the catchment area for the material preserved in the fills may have been small (Bakels forthcoming). The area farmed around the site could therefore have been quite restricted.

Materials and Methods

Palynological analyses were conducted on twenty-nine bulk sediment samples recovered from archaeological contexts during the 1983–87 excavations at Beaurieux Les Grèves. Standard laboratory techniques were used in preparing the samples (Moore et al. 1991). Alkali digestion with a 10% solution of Sodium Hydroxide disaggregated and removed organic material, after which acetylation was used to oxidise insoluble organic substances like cellulose and lignin. The high inorganic fraction in all the samples required the use of hot hydrofluoric acid and hydrochloric acid to remove silicate and carbonaceous mineral material. Silicone fluid was used to mount the stained pollen residue on microscope slides. To supplement the pollen data, non-pollen palynomorphs (NPPs) were counted. Mainly fungal spores, they were identified using the catalogue of the Hugo de Vries Laboratory at the University of Amsterdam (van Hoeve and Hendrikse 1998) compiled from published papers and

used in subsequent research (e.g. van Geel 1986, 2001; van Geel et al. 2003; van Geel and Aptroot 2006). Where NPPs cannot be identified to taxon, they are shown with the 'Type' numbering system used in the manual, with the prefix 'HdV'. This HdV code is shown on the diagrams and at the first mention of a named taxon in the text.

Pollen and NPPs were counted on a standard light microscope at x 400 magnification. Seven sampled contexts were found to be without palynological content (1156, 1320, 1321, 1326, 1756, 2110 and 4038). In most of the remaining samples, pollen preservation was variable, and most grains showed a degree of corrosion. Pollen concentration was also low but substantial counts were achieved. In most, a count of 200 land pollen, in addition to fern and moss spores, was made after prolonged counting, but in contexts 959, 4037 and 5217, only 100 grains could be recorded despite extensive scanning of slides. NPP counts reached 100 in all samples. Pollen identification follows Moore et al. (1991), modified to accord with modern taxonomy (Bennett et al. 1994), supported by type slides. Recognition of cereal type grains follows Andersen (1979) and Joly et al. (2007). The results of the pollen analyses are shown as Fig. 3, calculated as percentages of total land pollen. Although not included within the calculating sum, fern and moss spores and microcharcoal are shown as percentages of it. The NPP results are shown in Fig. 4, expressed as percentages of the total NPP sum. In both diagrams taxa are assembled into groupings of similar ecology. For pollen the groups are woodland/hedges, heathland, ruderals/waster ground, cultivation, grassland/pasture and wet conditions. For NPPs the groups are burning, wood, plant remains/dung, erosion, wet conditions and grassland. Pollen types are grouped following Stace (1991) and according to Behre (1981, 1986) and a range of published papers. NPP types follow van Hoeve and Hendrikse (1998) and the extensive NPP literature (Miola 2012). Chronological phases and context numbers are shown on the figures, which were constructed using the TILIA program of Grimm (2004). Microscopic charcoal particles (microcharcoal) are those which passed through the 180 μm sieve during pollen preparation. They were counted on the pollen slides relative to the standard pollen count (e.g. Clark 1982; Robinson 1984) and are shown on Fig. 3 expressed as a percentage of the total pollen sum.

Palynology of archaeological sediments

Care must be taken in the interpretation of pollen data recovered from archaeological contexts such as buried soils and the fills of features such as pits and ditches (Greig 1982, 1986; Dimbleby 1985). Corrosion, as noted in some of the grains from this site, will have affected different pollen types differentially, so that the more resistant grains may be over-represented in such pollen spectra. Pollen

in mineral soils tends to be prone to mixing as the deposit forms, mostly due to invertebrate activity (Munaut et al. 1968). Also, the sources of much of the pollen in pit and ditch contexts may be unclear. The sediment fills of negative archaeological features may well be a mixture of the contemporary pollen rain from local vegetation and older pollen, perhaps contained in soil fallen from the sides or edges of the feature or washed in from further away. Pollen-bearing material, perhaps brought deliberately by people from some distance, may also be discarded in pits or ditches. Infilling can also occur as a series of phases rather than as a continuous process, so that the pollen contained in a primary silt at the base of the feature will record events shortly after its construction, whereas the series of higher fills will preserve a more heterogeneous sediment perhaps deposited after the feature has been cleaned out several times or finally disused.

Although there may therefore be doubts regarding the taphonomy of pollen data from archaeological contexts and how reliable and representative they are, their analysis is still worthwhile as it provides evidence for on-site and near-site vegetation, and land use associated with the archaeological site economy (Tipping et al. 2009; Brun 2011). At settlement locations away from natural organic deposits, on-site palynology may provide the only source of such environmental data, as a valuable complement to plant macrofossil evidence, as at Beaurieux Les Grèves (Bakels forthcoming). There is now a substantial recent literature of combined palynology and plant macrofossil analysis from on-site sediments (e.g. Akaret et al. 1999; Pokorný et al. 2006; Mariotti Lippi et al. 2009; Mercuri et al. 2013; Święta-Musznicka et al. 2013; Halvorsen and Hjelle 2017) which demonstrates the value of such analyses, but it is important that the archaeological pollen assemblages are assessed as reliable, before interpretation can be made. We have followed the assessment criteria proposed by Bunting and Tipping (2000, 2001) and Tipping et al. (2009), mainly regarding the preservation of grains and the ratio of robust to fragile pollen types. At Beaurieux les Grèves although some grains had suffered corrosion it was not advanced and there were none that were unidentifiable. Filicales (Pteropsida) spore frequencies are not high, at 20% or less, and would have been far higher in badly compromised assemblages. We therefore consider that, although preservation of pollen grains was of variable quality at Beaurieux, total counts were high enough to provide reliable palynological evidence. The recovery of NPP data, mainly algal and fungal spores, from the archaeological contexts in itself validates the palynological methodology, adding to the very few NPP analyses from sites in north-east France (Etienne et al. 2011), archaeological or natural. NPP analysis of archaeological context sediments is still an uncommon technique, not only in north-east France, but in general (van Geel et al. 2003; Innes 2004; Revelles et al. 2016).

Results and Interpretation

The context samples on Figs. 3 and 4 are arranged by chronological phase with the older contexts at the bottom of the diagrams. Presentation of results follows this order. Contexts from the same feature are boxed and listed in stratigraphic and therefore chronological order, otherwise contexts are listed numerically within phases. The results for three buried soils of uncertain but pre-Roman age are shown as a separate group at the top of the diagrams. A summary of the results of the plant macrofossil analyses for each phase by Bakels (forthcoming) is included to compare with the palynological interpretation.

Phase 1: 8 th to 6 th centuries BC

Contexts: 204 (upper fill of palisade ditch); 1824 (upper palisade gully)

The pollen results for this phase both come from fills of the first palisaded enclosure, to the north and south of the entrance. The results are so similar that they may be considered together. Tree and shrub pollen frequencies are very low, with only a little *Alnus* (alder), *Corylus* (hazel)-type and *Salix* (willow) present. Poaceae (grasses, c.f. Gramineae) and *Taraxacum* (dandelion)-type dominate the assemblage, with high values for other weeds of grassland or open, disturbed or bare ground such as *Plantago lanceolata* (ribwort plantain), Apiaceae (parsley family), *Anthemis* (chamomile)-type, *Rumex* (sorrel), *Artemisia* (mugwort) and Brassicaceae (cabbage) family. Large grass grains of cereal type occur and *Pteridium* (bracken) values are high. The two NPP assemblages are also similar. Although the records are quite diverse, they include significant frequencies of taxa that are associated with pasture or grassland (such as *Puccinia* (HdV-357) and cf. *Byssothecium circinans* (HdV-16), and those likely to indicate local Cyperaceae (sedges) such as HdV-18 (Mighall et al., 2006) and *Clasterosporium* (HdV-25). Others like *Chaetomium* (HdV-7A), *Cercophora* (HdV-112) and Sordariaceae (HdV-55A and HdV-55B) are general decomposers of organic material, although could indicate animal dung. *Glomus* (HdV-207) is prominent and indicates the erosion of soil material into the ditches (van Geel 2001). Of interest is the appearance of low percentages of algal taxa indicating shallow water or wet soil, *Zygnema* (HdV-58), *Spirogyra* (HdV-130) and *Mougeotia* (HdV-313). *Zygnema* is often found in such archaeological ditch fills (van Geel 1976), and these ditches must have had wet basal deposits, at least intermittently.

The pollen and NPP data suggest an almost completely deforested, open terrain dominated by grassland, probably pasture, with some waste ground. There was probably some agricultural activity in

the area. Few macrofossils were found by Bakels in this phase, but cereal remains and weed seeds occurred, probably from domestic or nearby contexts.

Phase 2: later 2 nd to early 1 st century BC

Contexts 380 (lower pit fill); 959 (from building D); 2622 (pit 3004); 2661 (gulley fill); 3011 (pit fill)

Two of these samples come from structural features (959 is from a Building D post pit; 2661 is from a gully within Building F); the rest are from late Iron Age pits (one within building F). All five pollen assemblages are broadly similar in showing a flora dominated by herbaceous plants with very low representation of woody taxa. Poaceae, *Taraxacum*-type and *Anthemis*-type are still most important. Compared to phase 1, *Plantago lanceolata* and *Pteridium* are reduced in frequency while *Silene* (campion)-type and Amaranthaceae (goosefoot family) are increased, perhaps indicating less grazed grassland and more arable land than in the previous phase. Cereal-type pollen occurs in all contexts except 959. Nitrophilous taxa like Amaranthaceae and *Urtica* could be associated with habitats around buildings themselves. Other probable arable herbs include *Stellaria* (chickweed)-type and *Centaurea cyanus* (cornflower), although the former is less diagnostic. Context 959 differs from the others in having no cereal pollen and a significant amount of *Quercus* (oak) pollen and it may reflect a slightly more wooded phase prior to complete clearance for cultivation, or woody material brought into the building, perhaps as fodder for stalled animals (Innes 2004; Innes and Rutherford 2009), twigs and leafy branches often being an alternative fodder to hay (Rasmussen 1989, 1993; Delhon et al. 1998; Hejcmanová et al. 2014). The NPPs show some variability between the five contexts although the main contributors, *Chaetomium*, Sordariaceae and *Cercophora*, are all relatively consistent. Dung fungi are common, mainly *Sporormiella* (HdV-113), *Podospora* (HdV-368) and *Tripterospora* (HdV-169), reflecting the concentration of animals around farm buildings and in surrounding areas. Little *Glomus* is present, suggesting little input of soil material. *Pleospora* (HdV-3B) in consistently present, and grows on dead plant tissue, likely to be material brought to the site, perhaps for bedding. Mighall et al. (2006), however, suggested its association with *Sporormiella*, and the incorporation of dung and plant material into these ditch fills seems likely. Bakels' (forthcoming) suggestion that dung may have been brought to the site for fuel (Miller and Smart 1984) is supported by the NPP data. Only the primary fills from context 380 (Pit 443) contain evidence of wet conditions within the features, with *Mougeotia* and *Zygnema* present. This is supported by substantial frequencies of Cyperaceae and fungal type HdV-18, which often occur together (Mighall et al. 2006). There are few NPP indications of wooded conditions as suggested by the *Quercus* pollen of context 959 (Building D), only a slight

peak of *Coniochaeta xylariispora* (HdV-6) having woodland affinities. Two contexts, 3011 and 2622 contain elevated frequencies of microcharcoal, although still not very high. Macroscopic charcoal was recorded in both contexts during excavation, accounting for the increased microcharcoal content.

The pollen and NPP data suggest mixed agriculture, probably with meadow, pasture and waste ground around the site itself and cereal fields rather further away, although not too far as cereal pollen is poorly transported (Vuorela 1973). The bulk of the NPP data derives from the waste plant material that would have been present in domestic farmyards. Bakels' macrofossil evidence shows considerable cereal remains, wheat and barley, with seeds of wild herbs of fields and grassy patches. The assemblage probably derives from plant remains collecting in domestic areas and farmyards, with an important bedding and fodder component, thus agreeing with the palynological data.

Phase 3: Later 1st century BC/Augustan

Contexts 1159, 1158, 1152 (upper, middle and lower/primary fills from ditch 2S); 1157, 103, 1160 (upper, middle and lower/primary fill from ditch 2N; 1327 (primary fill ditch 1S)

These samples fall into two sub-groups and this division is reflected in their pollen records. All seven contexts are ditch fills, one from Ditch 1 South and six from Ditch 2 North and South. However, contexts 1152, 1160, and 1327 are from the primary or lower fills, whereas the others are from middle or upper fills. The primary fill samples are characterised by higher tree and shrub pollen frequencies, number 1327 from Ditch 1, the earliest, being the most extreme case, where woody taxa account for more than 50% of total pollen, *Corylus*-type being most important. A wider range of woody taxa occurs, including *Betula* (birch), *Tilia* (lime) and *Crataegus* (hawthorn) type, and *Polypodium* (polypody fern) which is often associated with shady wooded conditions, is recorded. They are also without cereal type pollen and the herbs of cultivation, grassland and disturbed habitats are greatly reduced in variety and abundance. Wetland taxa are more important, for example *Typha angustifolia* (lesser reedmace) and Cyperaceae (sedges). It is likely that these samples reflect conditions soon after the cutting of the ditches, with damp habitats within the ditches themselves, in a still partly wooded area prior to intensive agricultural activity. In contrast the middle and upper ditch fills all contain very high frequencies of grass and weed pollen, including arable indicators like Amaranthaceae and Cereal type, and very low tree and shrub percentages. This pollen evidence may be attributable to a later stage in the occupation of the site during this phase, with the development of more intensive farming activity closer to the site after land clearance. The NPP data tend to support the pollen interpretations. In

context 1327, which has higher tree pollen frequencies, some fungal types that indicate more wooded conditions occur, including *Pleospora*, *Coniochaeta xylariispora*, *Hypoxylon argillaceum* (HdV-327) and *Helicoon* (HdV-30). As well as growing on dead plant material, *Pleospora* has been noted as having an affinity with woodland (Blackford et al. 2006). Unless woody material was introduced to the ditch, there may have been some scrubby woodland near the site, perhaps managed for fuel, or else the presence of hedges used for land division at the site. Higher *Glomus* percentages indicate input of soil material as the ditch fills accumulated, whether by dumping of material or by erosion from ditch sides cannot be known. In primary or lower ditch fill 1152, algae including *Zygnema* and *Mougeotia* indicate damp conditions in the bottom of the ditches after they were first cut. All the contexts in this grouping contain the general suite of NPP fungal spores that were introduced as the fills accumulated, with dung fungi *Sporormiella* and *Tripterospora* indicating animal husbandry, amid the more cosmopolitan decomposers Sordariaceae and *Cercophora*. Frequencies of *Puccinia* are substantial, indicating grassland nearby for most of the samples.

Again, the combined pollen and NPP data for this group of contexts suggest mixed farming with pasture nearby. Some regrowth of scrub woodland is suggested at the time of context 1327, probably quite close to the site given the elevated tree and shrub pollen values. Bakels' macrofossil data is confined almost entirely to cereal remains, with a few grass and weed seeds, and again resembles a crop waste assemblage. It agrees with the palynological data in reflecting the presence of cultivation.

Phase 4: 1st century AD

Contexts 1322, 1328 (upper and primary fills from ditch 3/4S); 4037 (building posthole fill); 5217 (lower pit fill)

These samples form a diverse group, but are alike in having very low tree and shrub pollen frequencies and being dominated by herb pollen, particularly Poaceae, *Taraxacum*-type and *Anthemis*-type, with a wide range of less abundant grassland and arable weeds. All contain high frequencies of Cereal type pollen. Context 1328 is a primary ditch fill (Ditch 3/4 South), but the open terrain suggested by the pollen data points to the ditch having been excavated when the area was already the site of intensive agricultural activity. *Polygonum aviculare* (knotgrass) and *Centaurea cyanus* both occur and are indicators of arable cultivation. The upper ditch fill of context 1322 (also Ditch 3/4 South) contains fewer such indicators but is otherwise very similar indeed. The fill from Building C posthole 4037 is very different in being almost completely dominated by herb indicators of pasture rather than arable agriculture, although the area is just as open as in the other contexts and cereal-type pollen occurs.

Plantago lanceolata is abundant and the variety of weeds recorded is very low, suggesting grassland, probably grazed meadow (Andersen 1993) rather than waste ground, close to the site. Context 5217 (Pit 5218) is similar, although *P. lanceolata* is less important.

A *Calluna* (heather) peak is a feature of context 5217, with very few other pollen taxa except for *Taraxacum*-type and Poaceae, and low frequencies of *Anthemis*-type, Cereal-type and *Plantago lanceolata*. Poaceae values are very high. *P. lanceolata* is less important than in the other contexts of this phase, and Poaceae and *Taraxacum*-type together account for over 70% of total pollen. It represents an open grassy vegetation with reduced levels of farming activity, at least near the site, but with some expansion of heathland nearby. Finally, contexts 1322, 1328 and 5217 may reflect a time when arable agriculture had rather declined, although cereal pollen is still recorded, and some areas have been allowed to return to grassland or waste ground. High frequencies of *Cercophora* and Sordariaceae might suggest the input of plant material, perhaps with dung as *Sporormiella* frequencies are substantial. The basal fills of 1328 were wet, with occurrence of *Zygnema*, *Spirogyra* and *Mougeotia* algae.

This phase suggests mixed farming but with considerable cereal cultivation, although the area around the site was mainly grassland or waste ground. It would have been a phase of quite intensive farming activity. Bakels' macrofossil evidence comprised considerable cereal remains but also contained many grass and weed species, in contrast to phase 3. A combination of domestic waste and fodder is indicated (Bakels 1999), perhaps with plant material brought from a wider area than previously.

Phase 5: 2nd and 3rd centuries AD

Context 2101 (villa feature fill)

Context 2101 represents the infilling of one of two large rectangular basins at the centre of the Gallo-Roman villa. This infill belongs to the end of Phase 5, when the site was reorganised. A few finds from the surface of the basin suggest that material continued to accumulate here as a result of occupation continuing into the following century, but the pollen sample from 2101 should reflect local vegetation in the 3rd century AD.

The pollen from 2101 differs significantly from 1st century AD contexts such as 5217, with *Alnus* rising to replace *Calluna*, presumably through plant succession in wetter areas. The local presence of *Alnus* is supported by the record of *Diporotheca* fungal spores, saprophytic upon alder (Doyen and Etienne 2017). Although the cereal record indicates some cultivation, these grains could

be introduced from material brought to the site from some distance. There is no *Plantago lanceolata* and few weeds, so scrub may have existed close to the site. The NPPs are not diagnostic in this phase, represented by a range of general decomposers, although increased *Coniochaeta* cf. *ligniaria* and records of *Hypoxylon argillaceum* may reflect the increased counts for tree types, particularly *Alnus*.

Although this single context sample cannot be assumed to be representative of the wider site area as a whole, it seems that by this time a significant reduction in the scale of agricultural activity and some regeneration of natural vegetation occurred, at least near to context 2101, although the introduction of material from a distance must always be considered. Bakels' macrofossil data was mainly cereal remains with some field weed and grassland seeds.

Date unknown, but pre-Augustan
Contexts 1337, 1338, 1759 (buried soils)

Three samples were analysed from buried soil horizons that pre-date phase 3, but are otherwise essentially undated. Although from two different parts of the site some differences occur, these contexts are generally very similar. Herb pollen frequencies are high, with Poaceae, *Taraxacum*-type and *Anthemis*-type dominant as in other contexts. Tree and shrub values are considerable, however, with *Corylus*-type and *Alnus* particularly so and the less abundant types *Crataegus*-type, *Salix* and *Calluna* all present. The high Rosaceae (rose family) counts may represent similar shrub genera. Two of the three samples have no cereal-type pollen, and indications of active agriculture, such as *Plantago lanceolata*, are very limited. Although these buried soils cannot be related chronologically to the other contexts described in this paper, they appear to represent stages in the occupation when some scrub woodland cover still existed, prior to clearance and intensive agricultural land use. While the NPP assemblage is dominated by the more common general decomposers, Sordariaceae and *Cercophora*, there are increased values for types which may have affinities with woody plants. The wood saprophyte *Coniochaeta* cf. *ligniaria* and *Coniochaeta xylariispora* show peak percentages, while *Helicoon* and *Hypoxylon argillaceum* are important. *Pleospora* rises and has been noted as associated with hazel woodland regeneration (Blackford et al. 2006), which would accord with the *Corylus* pollen record here. The rise in HdV-10 in these soils agrees with the presence of *Calluna* pollen, being parasitic upon heather (van Geel 1986). Significant *Glomus* percentages are consistent with mineral soils (van Geel et al. 2003), growing on plant roots. Microcharcoal percentages are very low, suggesting reduced activity both on the site and around it.

These buried soils appear to record regenerating scrubby woodland and heath around the site. They may represent a period of abandonment, or at least reduced human activity, as indicators of grazing, such as dung fungi, are almost absent, and pollen indicators of agriculture are few. Of the other contexts, their assemblages most resemble those from Phase 1, but they could as easily represent periods of reduced farming activity later in the Iron Age. No plant macrofossil data are available.

Discussion

Near-site environment and vegetation

The pollen and NPP data allow reconstruction of the local environment at and near the site, complemented by the macrofossil data of Bakels (forthcoming). The geology and soils of the Aisne valley region are calcareous and free draining limestone and chalk (Bakels 1984) but in the valley bottom wet meadows prone to flooding are common near the river. In north-eastern France concentration of Iron Age and Gallo-Roman settlement in valley bottoms often made them vulnerable to flooding events, as in the 2nd century AD at Crévéchamps in the Moselle valley (Koenig 2016). At Beaurieux Les Grèves, Bakels identified seeds of plants of wetter soils and watersides, indicating the presence of damp meadow areas nearby, perhaps in shallow depressions on the Aisne floodplain. These, and the presence of some Cyperaceae and *Typha* pollen on the pollen diagram, and that *Alnus* is prominent among the low tree and shrub pollen count, suggest the presence of wetter areas, either naturally off-site or in the ditches and gulleys on-site. The finding of algal spores and wetter NPP types, especially in the primary silts of the ditches at various phases of the occupation, suggests the latter. As suggested by Haselgrove (1990; 2007b) the land around the farmstead buildings seems to have been meadow or pasture, or at least grazed grassland, with grass and weed pollen dominant, and significant frequencies of several fungal spore taxa that are likely to indicate animal dung (van Geel et al. 2003). In this regard *Sporormiella* is an obligate coprophilous fungus, and its frequencies could be a measure of numbers of grazing animals (Davis and Schafer 2006; Graf and Chmura 2006; Cugny et al. 2010), although local concentration of animals cannot be reconstructed if the dung has been collected and brought to the site, or results from cleansing of byres where beasts were stalled (Zimmerman 1999; Akeret and Rentzel 2001). Van Geel et al. (2003) recorded substantial proportions of ascospores of dung fungi in archaeological contexts at a Roman period settlement in the Netherlands, which indicated grazing around the site, and perhaps the collection of dung for fuel. Coprophilous fungi are often present in archaeological contexts (Buurman et al. 1995; van Geel et al. 2003; López-Sáez and López-Merino 2007; Mercuri et al. 2010).

At Beaurieux Les Grèves much of the pollen of weed plants that favour bare, disturbed ground may well have originated within the site itself, or on pathways or where stock have trampled ground (Sagar and Harper 1964; Behre 1981). The records for *Urtica* and other nitrophilous weeds will derive from the settlement area. Even though cereals are low pollen producers, the low pollen frequencies of cereal type pollen and arable type weeds (Brun et al. 2007) suggests that crop fields were not immediately adjacent to the settlement, but rather further away (Vuorela 1973). As will have happened with the macrofossil remains (Bakels 1999), some pollen indicators of cultivation may have been brought to the site with the crop, rather than by natural transport, and some of the herb taxa such as *Centaurea cyanus* and *Polygonum aviculare*, and possibly Amaranthaceae and *Stellaria*-type, are associated with cereal fields. There are no NPPs present that could be considered diagnostic of arable cultivation, although many of the general plant tissue decomposers like *Cercophora, Chaetomium* and Sordariaceae may have been brought to the site on fodder and crops (Bakels 1999).

The Beaurieux Les Grèves samples provide a useful time series of local vegetation history on and around this settlement through the Iron Age and Gallo-Roman periods, and probably represent a broadly accurate record of very local land-use changes during that period. Almost all the samples contain a mixture of agriculture, usually including cereal cultivation, grassland which was probably for pasture, and waste or broken ground which may well have been associated with the settlement itself. The proportions of these components vary, but whether this in every case reflects real differences in land use or is partly a taphonomic artifact cannot be known. Certainly, the abundance of *Taraxacum*-type pollen, often a feature of archaeological pollen analyses (Bottema 1975), will be due in part to its resistance to corrosion, although plants within that type will probably have been common in the local flora, with pollen perhaps brought with animal dung. Wild wetland grasses do exist which have cereal type pollen grains, such as *Glyceria* (Andersen 1979; Tweddle et al 2005; Joly et al. 2007), but these are extremely unlikely to appear in archaeological samples. The morphology of the Beaurieux Les Grèves pollen grains suggests they are of *Triticum* and *Hordeum* type and the associated pollen assemblage, supported by the plant macrofossil evidence suggests they are almost certainly cereals. Bakels (1984) also recovered seeds of *Triticum* and *Hordeum* from Iron Age contexts at Villeneuve-Saint-Germain, downstream of Beaurieux.

The shrub pollen that occurs suggests local growth of scrub in abandoned areas or perhaps around boundary ditches and buildings or within hedgerows. There is no evidence of any mature woodland nearby, although some must have existed within the wider landscape, and the land around the settlement must have been virtually completely cleared for agriculture since at least early in the period in question. Slight exceptions are the peak of *Quercus* pollen in context 959, the several higher

tree counts in 1327 and the high *Corylus*-type curve in the three buried soil contexts, 1338, 1337 and 1759. That 959 is unique among the sampled contexts in being from a building posthole suggests the oak pollen may be from exotic material transported from elsewhere by people. Context 1327 is a primary ditch silt, and so was deposited soon after the cutting of the ditch. This feature may have been associated with the start of a phase of occupation in a new area or one which had fallen out of use and allowed to regenerate woodland, or at least scrub. Any trees and shrubs near the site would presumably have been managed, and would have been a source of fuel. Buried soils, which take time to form, often contain evidence of stable vegetation conditions existing before the start of a phase of land-use change. It may be that the high hazel curve from these three examples reflects the semi-natural regeneration community which would occur on the dry calcareous soils around this site, although without their exact chronological context their development cannot be related to previous land use. Overall, the generally low *Calluna* curve suggests that land was not allowed to fall into disuse, although the local alkaline soil conditions would have favoured the establishment of rough grassland rather than heath in areas not actively used. Apart from a few contexts where macroscopic charcoal occurred, the microcharcoal frequencies are very moderate and probably derive from domestic fires, although an element may have been produced by land management activities at a distance from the site (Blackford 2000) such as stubble burning.

Comparative studies

The Aisne valley

The pollen data from the archaeological contexts described above are almost entirely local to the settlement and its surroundings and so may not provide evidence that is representative of Iron Age and Gallo-Roman vegetation history in the Aisne valley as a whole. Less local vegetation histories are available in pollen diagrams from natural deposits and these are important for reconstructing the wider extent of woodland and agricultural activity in the Aisne valley at this time, while palynological data from other archaeological sites will provide direct comparisons with the Beaurieux Les Grèves record. The location of palynological sites in the Aisne Valley is shown in Fig. 1c.

The valley seems to have been well wooded before the Iron Age. Examination of pollen spectra from Neolithic archaeological sites in the valley (Firmin 1977; 1982; Firmin et al. 1989; Boulen 2011; Blancquaert et al. 2012), as at Cuiry-lès-Chaudardes, Menneville and at Villeneuve-Saint-Germain, suggests that some deforestation had occurred for agriculture in the Neolithic, although probably only

at the settlements and in the area near to them. While pollen from archaeological contexts at these sites show open ground around the settlements, pollen data from natural peat deposits in a side-valley of the river Aisne at Maizy-Cuiry 2 km upstream from Beaurieux, in the neighbouring Vesle valley at Bazoches 15 km to the south-west (Bakels 1992, 1995; Boulen 2005, 2011) and at Vauxcéré (Vasseur 1990) in the Muison valley 2 km north-east of Bazoches show only a little evidence of disturbance of the Neolithic *Quercus-Tilia-Corylus-Ulmus* (elm) forest. Data from Maizy-Cuiry and Vauxcéré show that in the late Bronze Age of the Aisne Valley *Tilia* was important on the higher ground, but was gradually replaced by *Fagus* (beech) while *Ulmus* was replaced by *Alnus* in river valleys, and there was increasing human impact on the forest, although to a limited extent.

It is in the Iron Age and later, however, that much more extensive and major forest clearance, both on higher ground and on the valley floors, becomes apparent in the natural pollen record in the Aisne valley, mainly recorded in the peaty sediment sequence at Maizy-Cuiry (Chartier 1991; Bakels 1992, 1995). As this core is only 2 km from Beaurieux Les Grèves, but with a greater pollen source area, it provides data on the more regional vegetation around the settlement during its Iron Age and Gallo-Roman occupation. It shows that there was still significant woodland in the area, although much less than previously, composed mainly of oak and alder with beech finally replacing lime. Remaining tree cover probably existed on steeper slopes and on the plateaux, with greatly reduced alder surviving in the valleys. It also records, however, a major expansion of herbaceous vegetation, mainly grassland but with considerable cultivation of cereals. *Cannabis* and *Secale* (rye) were also grown. The same range of weeds that occurs at Beaurieux Les Grèves is recorded, especially *Plantago lanceolata*, Brassicaceae, Amaranthaceae, *Taraxacum*-type, *Anthemis*-type and *Ranunculus*-type. Fears that the on-site *Taraxacum*-type abundance was due to preservation bias in the cultural sediments, for example, seem to be unfounded. It appears that the grassland pasture, meadow and cultivated fields that characterise the Beaurieux Les Grèves archaeological pollen assemblages were not confined to the land immediately around the settlement, but also formed part of the wider vegetation, particularly in the valley bottoms. Macrofossil data at several archaeological sites in the Aisne area (Bakels 1984) suggest that by the La Tène Iron Age some chalk grassland existed on the upland, but the substantial frequencies of tree pollen at Maizy-Cuiry do show a more wooded regional terrain than the archaeological samples would indicate. A dichotomy between deforested lowlands and partially wooded uplands existed that will have persisted into the Gallo-Roman period.

The very open vegetation around Iron Age and Gallo-Roman Beaurieux Les Grèves is clearly mirrored in the pollen evidence from other archaeological sites of the period (Fig. 1c) in the Aisne Valley, supported by plant macrofossil studies. Data from the La Tène occupation at Villeneuve-Saint-

Germain some 30 km downstream is very similar to that of Beaurieux Les Grèves in being dominated by herb pollen in which *Taraxacum* (c.f. Cichoriées)-type is very abundant (Firmin 1977). Auxiette et al. (2003) recorded such a pollen assemblage at Villeneuve-Saint-Germain, but with substantial cereal frequencies, while at the same site, Innes (1984) recovered a pollen assemblage of La Tène date from Villeneuve-Saint-Germain La Grande Fosse, which was also dominated by Poaceae and *Taraxacum*-type, but with a wide range of weed pollen, *Pteridium* and some shrub types, indicating mainly local grassland with some scrub and waste ground. These data agree well with Bakels' (1984) macrofossil studies at the site. Other archaeological sites in the Aisne valley nearer Villeneuve-Saint-Germain, for example early La Tène contexts at Bucy-Le-Long (Boulen 2009), late La Tène ditches at Condé-sur-Aisne (Munaut 1988), La Tène tombs at Pernant (Girard 1969), and La Tène to Gallo-Roman sediments at Ronchères in the Vesle valley (Boulen 2010) were clearly surrounded by waste ground, meadows or grassland, probably for pasture, with occasional cereal cultivation. These sites also contain an anthropogenic pollen assemblage (Brun 2011) dominated by *Taraxacum*-type with some grasses. It is suggested (Firmin et al. 1989) that the preponderance of this weed pollen type may partly be related to selective grazing by stock, grasses being preferred before flowering while the *Taraxacum* group herbs are allowed to flower before being eaten. It is possible that this pollen type may have been transported in quantity to settlements in animal dung (Bakels 1999), which the fungal spore assemblage at Beaurieux Les Grèves suggests may have been locally plentiful at such sites. The site at Juvincourt on the Aisne floodplain 15 km upstream from Beaurieux (Munaut 1988) also records completely deforested land with extensive grazed areas. Although these settlement sites were set within a mostly agricultural but still partly wooded rural landscape, their archaeological pollen analyses indicate that the open, grazed grassland on and around the Beaurieux Les Grèves settlement, probably with high animal concentrations, was typical of all such sites in the Aisne valley. In this they are analogous to many late Iron Age settlements elsewhere in western and central Europe (e.g. Pokorný et al. 2006).

North-East France and environs

The off-site palynological record in the Aisne Valley described above is restricted but, combined with the on-site data, shows that considerable deforestation and changes in woodland composition occurred during Iron Age times. It is necessary to place the Aisne valley record in a wider context, however, to assess how representative it is of Iron Age and Gallo-Roman vegetation history in its region of north-east France and adjoining areas. Selected pollen sites of that age from the region are shown on Fig 1b,

ranging from cores to the south of Paris to some in Lorraine and Luxembourg. These pollen diagrams show that all across the wider region it was the Iron Age that saw the start of major deforestation (Munaut 1988; Leroyer et al. 2009; Koenig 2016, chapter 2), as recorded at Maizy-Cuiry and Beaurieux Les Grèves itself. By late Iron Age times deforestation and agricultural intensification had become very extensive indeed and, as in the Aisne valley, much of north-eastern France supported open vegetation and agricultural land (Leroyer et al. 2009; Boulen 2010; Malrain et al. 2015), with woodland surviving on wetlands, steep valley sides and on high ground (Mullenders 1960; Guillet et al. 1976; van Zeist and van der Spoel-Walvius 1980). A summary of the vegetation history from Beaurieux Les Grèves and from the wider region of north-eastern France is shown in Table 1.

A local comparison with the Beaurieux Les Grèves material comes from the pollen diagram from Chemin d'Emery (Fig. 1b), a natural organic profile on the valley floor of the River Retourne, a tributary of the Aisne, which lies close to the late La Tène and Gallo-Roman cemetery and settlement at Ville-sur-Retourne in the Champagne chalkland north-east of Reims and 50 km from Beaurieux (Beal et al. 1980). This natural pollen assemblage appears to show that the Aisne terraces and floodplain were almost completely deforested by the late Iron Age at least, and thus agrees very well with the evidence from Beaurieux Les Grèves and other sites from the Aisne valley floor (Firmin et al. 1989; Boulen 2009, 2010). The suggestion by Haselgrove (1990) that land near the farms was used mainly for pasture seems borne out by the NPP data from Beaurieux Les Grèves, with a considerable presence of dung fungi in the ditch and gulley fills. Much of the Chemin d'Emery diagram is very likely to span Iron Age and Gallo-Roman times and it is characterised by extremely high cereal (mainly *Triticum*-type) pollen values throughout, as well as abundant Poaceae and high Brassicaceae, *Plantago lanceolata* and *Taraxacum*-type. Pollen of arable weeds *Centaurea cyanus* and *Polygonum aviculare* are present, as at Beaurieux Les Grèves. Tree and shrub pollen frequencies are very low, but most important are *Fagus*, *Quercus* and *Corylus*-type, which supports the findings of other workers regarding the regional woodland away from areas of intensive cultivation. Most interesting, however, is the presence at Chemin d'Emery of pollen of cultural indicator plants which are present in the Beaurieux Les Grèves macrofossil data, but not in its pollen record. Papaveraceae (poppy family) and *Secale* (rye)-type cereal pollen are very well represented and *Cannabis*-type pollen (which may refer to either *Cannabis*, hemp, or *Humulus,* hop) is abundant, being the most common pollen type recorded in the lower half of the diagram, which is most likely to correspond to the Iron Age and Gallo-Roman levels. Natural deposits such as Chemin d'Emery may provide a much more complete record of human land use and its consequences in the Aisne area than the spatially restricted and locally sourced pollen data recovered from archaeological contexts like Beaurieux Les Grèves.

In the wider region the long pollen diagrams from Silly-la-Poterie, Coizard-Joches, Marais de Chivres, Fréchencourt and Vallée de la Voise remain the most important study of vegetation history (van Zeist and van der Spoel-Walvius 1980) and can act as standard regional pollen records. The first three are within 50 km of the Aisne valley (Fig. 1b). They are similar in showing the expansion of *Fagus* to dominate the forest with *Quercus* as a secondary tree and the major decline of *Tilia*. This natural change in forest composition (Munaut 1961; Planchais 1976) was probably driven by climatic deterioration and occurs in most pollen diagrams in the region from the start of the Sub-Atlantic climatic period (Magny 1993; van Geel et al. 1996), which coincides with the start of the Iron Age in northern France. *Fagus* may also have been favoured by human woodland disturbance (Bradshaw et al. 2010). The relative abundance of beech varies from site to site, with Silly-la-Poterie showing highest frequencies and Vallée de la Voise the lowest, but all record intensive agricultural phases and deforestation in the later Iron Age, often with particularly high *Plantago lanceolata* and *Secale* in a diverse weed flora, suggesting mixed farming. Analogous data, with very high *Fagus* massively reduced during an intensive phase of clearance and cultivation, occurred at l'Archet in the south of the region (Jalut 1967), with very high *Urtica* frequencies that reflected its location near to settlement sites. Much lower beech frequencies were recorded at nearby Poigny (Jalut 1966), but still with evidence of major late Iron Age cultivation.

To the west of the Aisne at Saumont (Fileux and Huault 1971) and at Long (Nilsson 1960) similar major woodland clearance for farming took place. In the east of the region near the river Meuse at the Tourbières de la Bar (Mullenders 1960) the situation is very similar, with *Fagus* expanding markedly in the Sub-Boreal within mixed *Quercus* woodland, then falling when very high Cereal-type, *Artemisia* and *Plantago lanceolata* frequencies, with *Fagopyrum* and *Centaurea cyanus*, enter the pollen record. River palaeochannel deposits adjacent to extensive Iron Age and Gallo-Roman archaeological sites at Crévéchamps in the Moselle valley in Lorraine (Koenig 2016) record a similar sequence of vegetation change, with beech gradually replacing oak during the Sub-Atlantic phase, and increasing levels of clearance for agriculture, until in Gallo-Roman times there was a highly degraded forest cover and most land turned over to cultivation, mainly of cereals. On-site palynology from well sediments at the site confirmed the very open nature of the vegetation at this time. To the east of the Moselle, Étienne et al. (2011) recovered pollen and coprophilous NPP assemblages from several small depressions (mardels) containing sediments that began forming in late Iron Age and Roman times. In every case increasingly major deforestation occurred from the Iron Age onwards, initially for mainly pasture, with high Poaceae, *Plantago lanceolata* and *Sporormiella* spores, followed in Roman times by a switch to cultivation of cereals and a big reduction in pasture indicators. To the north-east of the

Aisne in Gutland, southern Luxembourg, peaty deposits in similar mardels preserve pollen records covering the Iron Age and Roman periods (Slotboom 1963; Slotboom and van Mourik 2015). Several of these depressions are alike in recording the replacement of *Quercus* by *Fagus* in Sub-Atlantic times, then the repeated marked reduction of beech woodland and expansion of cereal, *Plantago lanceolata* and Poaceae pollen percentages during deforestation for agriculture.

The evidence from the Aisne valley and many regional sites therefore indicates that the Iron Age and Gallo-Roman vegetation history in north-east France is very consistent. It was characterised by increasingly severe clearance of woodland and the expansion of agriculture, culminating in deforestation and the development of intensive cereal cultivation in Roman times. So widespread were these changes that it is possible (Dambrine et al. 2007) that northern France's modern vegetation diversity patterns were established during Gallo-Roman times.

Conclusions

The palynological investigations at Beaurieux Les Grèves, integrating pollen and NPP analyses from archaeological contexts, have provided records of palaeoenvironmental conditions for more than a millennium at and around a multi-period rural farmstead which, allied to plant macrofossil data (Bakels forthcoming), have allowed the reconstruction of local land-use history at intervals throughout the pre-Roman and Gallo-Roman Iron Age in north-eastern France. The pollen data indicate open land, probably grazed, at and around the settlement from the early Iron Age onwards, but with periods when agriculture was reduced in intensity locally or even abandoned altogether. Evidence of both arable cultivation and animal husbandry are recorded in the land-use record from the site. This agrees with the pollen record from natural sediment profiles in the Aisne valley and regionally, although these show that there was a significant amount of woodland, mainly beech, oak and alder, remaining away from settlement locations, fields and pastures. Throughout the region major clearance for cultivation took place in the late Iron Age and Gallo-Roman periods, with *Fagus* woodland mainly affected.

The use of NPPs to complement pollen analyses is becoming more common, although most studies have used natural sediment profiles to provide continuous records of vegetation and land-use change. Such integrated studies have been relatively rare on archaeological on-site sediments (e.g. Clarke 1999; van Geel et al. 2003; Innes 2004; Revelles et al. 2016) where the taphonomy of deposits within contexts such as pits, ditches and postholes can often be uncertain. At Beaurieux Les Grèves, however, the pollen and NPP data support one another well, and together allow a more secure interpretation of changing conditions through the occupation of the site. It is suggested that, where sediments from archaeological contexts are being investigated palynologically, NPP analyses should

be routinely added to pollen data to enhance the interpretation of palaeoenvironmental change on and around the site itself. Although the palynological data will be mostly derived from land at and near to the site (Tipping et al. 2009), the pollen source areas for archaeological sediments will have been spatially greater than that of plant macrofossils, which derive from on-site activities. Where the assemblages can be shown to be reliable, therefore, archaeological palynology should be undertaken in conjunction with plant macrofossil analyses to provide a more spatial reconstruction of land use.

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Captions to Figures.

Figure 1.

Map of northeastern France and adjacent areas of Belgium and Luxembourg, showing the location of the Aisne valley study area. Towns are shown as black squares. Palynological sites mentioned in this paper are shown as black circles in sections 1b and 1c. MCD refers to Mardel Closed Depressions. The location of Beaurieux Les Grèves is shown in Fig. 1c as a star.

Figure 2.

Plan of the principal features excavated in 1983-1987 at Beaurieux Les Grèves, showing the location of contexts sampled for palynology.

Figure 3.

Pollen results from archaeological contexts at Beaurieux Les Grèves, calculated as percentages of total land pollen (trees, shrubs and herbs). Contexts are shown at the right-hand side of the diagram, with the following chronological phases to which they correspond: 1 Eighth to sixth centuries BC; 2 Later second to early first century BC; 3 Later first century BC to Augustan; 4 First century AD; 5 late first to third centuries AD; 6 early to mid-fourth century AD. The final group of contexts comprises buried soils of unknown age, but pre-dating Phase 4. Contexts from the same archaeological feature are shown in stratigraphic order and are boxed. Other features are shown in numerical order within phases.

Figure 4.

Non-pollen palynomorph (NPP) results from archaeological contexts at Beaurieux Les Grèves, calculated as percentages of total NPPs. Chronological phases for the contexts shown on the right-hand side of the diagram are as in Figure 3. Contexts from the same archaeological feature are shown in stratigraphic order and are boxed. Other features are shown in numerical order within phases.

Caption to Table 1

Summary of local (Beaurieux Les Grèves) and regional (north-eastern France) vegetation during the Iron Age and Gallo-Roman periods.